Peat Water Treatment by Electrocoagulation using Aluminium Electrodes

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Abstract. Peat water is surface water that flooded an area formed by the files of organic material over a long period. The characteristics of the peat water is a low pH (3-4) that is highly acidic, has a high organic content, high levels of iron (Fe) and manganese (Mn), as well as yellow or dark brown (concentrated). One of the peats is formed in the Integrated Independent City, Ogan Ilir Regency, South Sumatera. The formed feat water contains Fe and Mn high enough for it to be analyzed for the peat water treatment to reduce the levels of Fe and Mn metal using electrocoagulation. The electrocoagulation is performed in batch with electrodes dimensions are 18cm x 6.5cm x 0.2cm and the distance between is the electrodes 1cm. The aluminum electrodes are contacted with peat water by varying the current density of 20 A/m^2, 40 A/m^2, 60 A/m^2 and 80 A/m^2 and varying the processing time is 30 minutes, 60 minutes, 90 minutes and 120 minutes. The result showed that the optimum pH rise occurs at 40 A/m^2 current density with a time of 30 minutes and decrease the effectiveness of each parameter occurs at 20 A/m^2 current density with the processing time of 120 minutes. The decrement of TDS effectiveness is 42.09%, BOD5 34.36% and COD 88.89%, while the decrement of the effectiveness of the Fe and Mn metal content were 55.2 % and 90 %, respectively. The results indicate that electrocoagulation method can reduce water pollutants contained in the peat water. The results of this processing have fulfilled the standards of the Ministry of Health.

1. Introduction

Water is a basic need for human life. In daily life, humans always need water especially for drinking, cooking, bathing, washing, etc. The regions that have not yet received clean water services, residents usually use dug well water, river water which sometimes or often does not fulfill the standard of safe drinking water, even for regions that has an inferior quality of groundwater and river water, residents only use rainwater to fulfill the need of drinking water. Especially for residents who live in peat swamps in parts of Sumatera and Kalimantan have difficulty in providing clean water due to the water contained in that regions is acidic (low pH), brown color and contains organic [1].

The potential of peatlands in Indonesia is enormous, which is around 14,905 million hectares. Most of them are spread in Kalimantan, Papua, and Sumatera. This condition allows people living around the area who experience difficulties in the availability of clean water using peat water to fulfill their needs [2]. The principle is that peat water is surface water or groundwater which is widely found in tidal areas, swampy and lowland areas, brownish red, acidic (high acidity), and has high organic content.

Peat is defined as an organic material which is formed from the imperfect decomposition of plants in wet areas and very humid conditions and lack of oxygen [3].

Peat water has a quite high Fe and Mn composition which is indicated by the red and brown color of peat water. Because the Fe and Mn content is quite high, it is necessary to do processing using electrocoagulation [4, 5].

Based on these studies it can be seen that the electrocoagulation method has the potential in purifying peat water and decreasing the metal content contained in peat water such as Fe and Mn without the addition of coagulants [6].

Metal content such as Fe (iron) and Mn (manganese) in water can cause the color of cloudy and brown water. The effect of manganese if consumed by humans in excessive doses will lead to chronic poisoning and can cause weakness in the legs and muscles, whereas iron if consumed in large quantities, can have a detrimental effect on the intestinal wall and reduced lung function. Therefore, it is necessary to process heavy metals Mn and Fe so that the water quality is following drinking water quality standards [7].

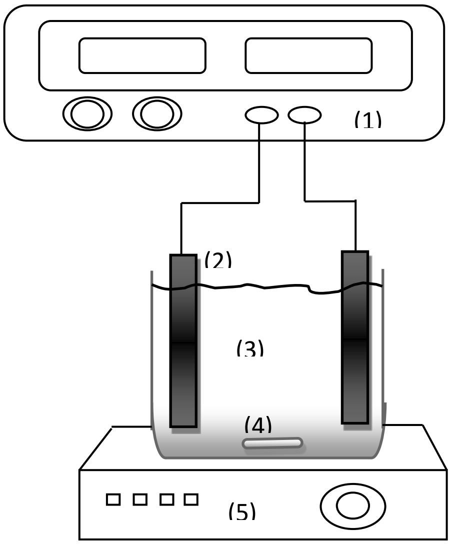
Electrocoagulation is an electrochemical water treatment method wherein anoda occurred the release of active coagulant as a metallic ion, while in cathode occurred the electrolysis reaction in the form of the release of hydrogen gas [8,10,15]. Electrocoagulation is a complex process that involves chemical and physical phenomena by using electrodes to produce ions used to treat wastewater. Currently, the use of electrocoagulation technology is developed to improve the quality of wastewater effluent. Electrocoagulation is used to treat effluents from several sources of wastewater from the food industry, textile waste, household waste, waste containing arsenic compounds, water containing fluoride, and water containing fine particles, bentonite and kaolinite [9,11]. Electrocoagulation can process a variety of pollutants including suspended solids, heavy metals, ink, organic materials (such as domestic waste), oils and fats, ions and radionuclides. The characteristics of pollutants affect the processing mechanism, for example, ion-shaped pollutants will be reduced through a precipitation process while the suspended solids will be absorbed into the charged coagulant [12-14].

2. Methodology

The peat water treatment research conducted using electrocoagulation method. The coagulation used is an aluminum electrode. The data collection process was taken 16 times with variations in current density and processing time in waste treatment. The research carried out has an experimental design as follows:

- The sampling of peat water comes from Integrated Independent City, Ogan Ilir Regency, South Sumatera.
- The initial characteristics of peat water with parameters measured by pH, TDS, BOD_5, COD, Fe metal content, and Mn metal content.
- Electrocoagulation process using an aluminum electrode.
- Measurement of increase in pH value and the decrease in TDS, BOD_5, COD, Fe metal content and Mn metal content.

The electrocoagulation process was carried out on an electrocoagulation reactor using aluminum electrodes on the anode and cathode. The electrocoagulation reactor is equipped with DC Power Supply and hot plate so that it can use a magnetic stirrer to stir and homogenize peat water. The scheme of the electrocoagulation process with an electrocoagulation reactor can be seen in Figure 1.



Information:

1. DC Power Supply
2. Aluminum Electrodes
3. Peat Water
4. Magnetic Stirrer
5. Hot Plate

Figure 1. Electrocoagulation Reactor

3. Results and Discussion

Preliminary analysis was carried out on peat water taken from Integrated Independent City, Ogan Ilir Regency, South Sumatera. The analysis was carried out before the treatment process by electrocoagulation method by analyzing the values of pH, TDS, BOD_5, COD, Fe content and Mn content. The results of the analysis can be seen in Table 1.

Table 1. Characteristics of Peat Water

No.	Type of Analysis	Quality Standards	Analysis Results
1.	pH	6 – 9	5.59
2.	TDS (mg/L)	50	49.8
3.	BOD_5 (mg/L)	2	1.95
4.	COD (mg/L)	10	9
5.	Kadar Fe (mg/L)	0.3	1.25
6.	Kadar Mn (mg/L)	0.1	0.09

Source: Environmental Quality Standard based on South Sumatra Governor Regulation No. 16 of 2012

3.1 Characteristics of Peat Water after Processing

This test was conducted to determine the effect of the best current density variation and processing time in terms of increasing the pH value and decreasing the value of TDS, BOD_5, COD, Fe levels and Mn levels by comparing the results of the final analysis of each treatment with the results of the initial analysis so that it can the most effective conditions that have the highest pollutant removal values are known.

From the results of the initial analysis of peat water in Table 1, the values of TDS, BOD_5, COD, and Mn levels did not exceed the standard of clean water quality. However, the pH value needs to be raised to reach the normal pH value of 7 because the pH value which is not normal can interfere with the life of organisms in the water such as fish and other animals and are corrosive to metals which cause rust and cause tooth decay and abdominal pain. Excessive levels of Fe in water can stain fabric and kitchen utensils, causing the color of the water to become brownish red, and can cause health problems such as intestinal disorders, unpleasant odors and can cause cancer.

3.2 Results of Peat Water Treatment with Electrocoagulation Method

3.2.1 Effect of Current and Process Time on pH Increase

In Figure 2, it can be seen that the increase in pH in peat water with an initial pH of 5.59 which is still in the acid category, after processing, there was a significant increase in pH which reached pH 7.87. The increase in pH in the electrocoagulation process occurs because of the alkalization process of Al_3^+ ions added in water so that a reaction with hydroxy ions occurs from the hydrolysis of water which produces Al $(OH)_3$ and hydrogen ions.

In addition to hydrogen gas, it will also produce hydroxide ions $(OH)^-$, the smaller the current density is used, the faster the reaction will occur, and the OH^- produced will increase so that it will increase the pH in the water. During the electrocoagulation process, these reactions occur which will increase pH.

In Figure 2 it can be seen that pH tends to increase with increasing processing time with a pH range of 7-8. The best result in pH increase is that it occurs at a current density of 40 A/m^2 with a processing time of 30 minutes which produces a pH of 7.87.

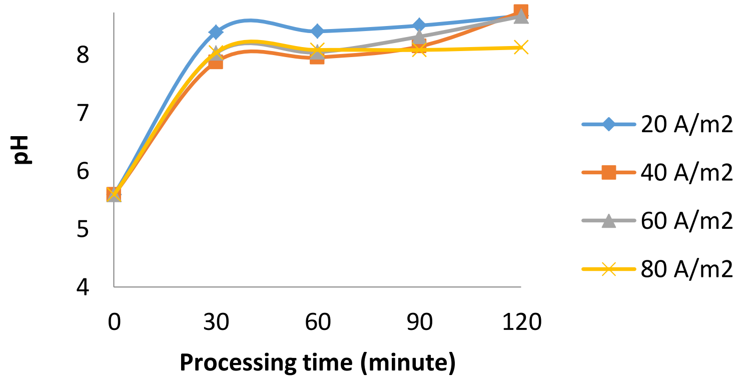


Figure 2. Effect of Current and Processing Time on pH Increase

3.2.2 Effect of Current and Process Time on Total Dissolved Suspended (TDS)

Decreasing the TDS value of electrocoagulation is very effective where electrocoagulation will produce less affluent with less TDS content. This decrease in TDS value can occur when double-layer compression occurs around the charged species due to the interaction with the ion formed from oxidation at the electrode. These ions cause reduced repulsion between particles in water so that the coagulation process can take place.

In Figure 3 it can be seen that the best decrease in TDS value is at a current density of 20 A/m^2 with a processing time of 120 minutes where the TDS value in that state is 28.84 mg/L from the initial state of 49.8 mg/L, and this result meets the standard quality.

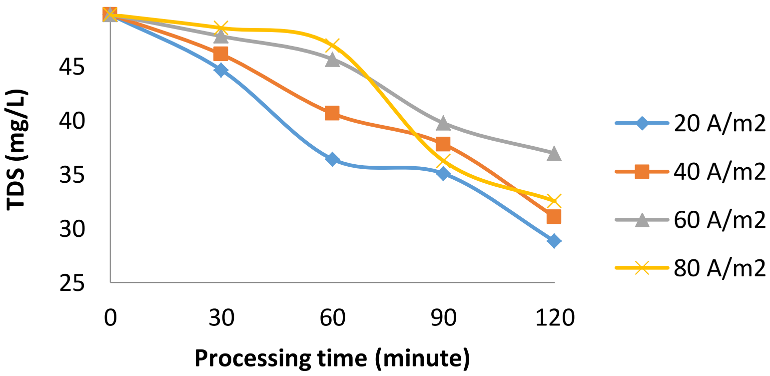


Figure 3. Effect of Current and Processing Time on TDS Value

3.2.3 Effect of Current and Process Time on BOD_5

In Figure 4 the results of peat water electrocoagulation on BOD_5 values appear to be decreasing. From the graph, it can be seen that the best results for the decrease in BOD_5 value occur at a current density of 20 A/m^2 with a processing time of 120 minutes. At the time of the process, there was a decrease in the BOD_5 value of 1.95 mg/L to 1.28 mg/L.

The results of this BOD_5 analysis determine the quality of the water body which is the amount of oxygen needed by the organism to destroy the organic material at a particular time. High BOD_5 values play an essential role in determining the ability of water bodies to support the growth of algae and aquatic organisms which will lead to increased growth. If the number of bacterial populations is getting higher, then the level of water pollution is higher.

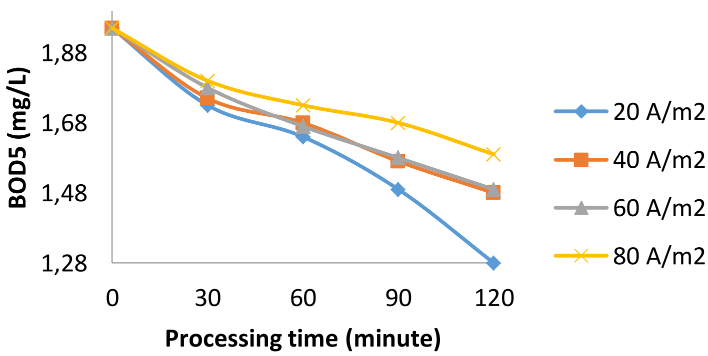


Figure 4. Effect of Current and Processing Time on BOD_5 Values

3.2.4 Effect of Current and Process Time Meetings on COD

COD was the quantity or number of oxidants that react with samples under certain conditions. The amount of oxidant used was proportional to oxygen demand. Organic and inorganic compounds in the sample were oxidized subjects, but organic compounds were more dominant. COD was often used as a measure of the number of pollutants in water.

In Figure 5 the results of peat water research before processing were obtained COD values of 9 mg / L, after processing the value of COD decreased. Significantly decreased COD values occur at the same current density of 20 A/m^2 at a 120 minute processing time of 1 mg/L. The standard threshold for COD quality was 10 mg/L.

The process of decreasing the COD value in electrocoagulation occurs through destabilization. Colloidal destabilization was carried out by metal cations which form polyvalent polyhydroxide. This complex compound had a high adsorption side so that it could facilitate the aggregation process with various pollutants that form floc which was easily separated by flotation techniques because the floc density becomes smaller.

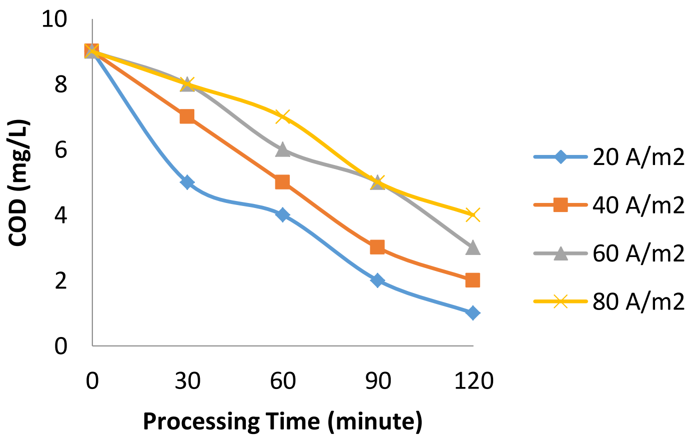


Figure 5. Effect of Current and Processing Time on COD Value

3.2.5 Effect of Current and Process Time on Fe and Mn Content

From the experiments that had been carried out obtained data that every change in current density and length of processing time would result in different electrocoagulation efficiency. The processing time dramatically affects the Fe content found in peat water, the longer the processing time, the lower the Fe content in the filtrate obtained, this happens for every variation of current density. From Figure 6 it could be seen that the reduction in Fe content in the largest peat water was achieved at 120 minutes at 20 A/m^2. In this condition, the Fe content in the filtrate was 0.56 mg/L, and the Mn content in the filtrate was 0.009 mg/L.

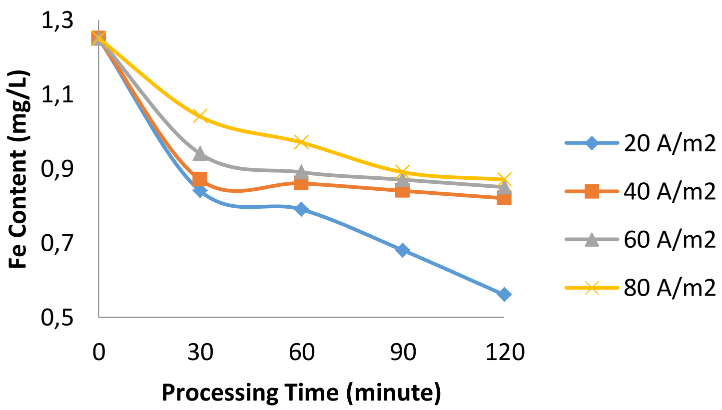


Figure 6. Effect of Current and Processing Time on Fe Content

Decrease in Fe and Mn content in the electrocoagulation process could occurred due to changed in electric current so that a magnetic field occurred around the electrode, Fe and Mn ions would move with a helix-shaped path around the electrode plate so that at that time there was a tendency for Fe^{2+} ions to stick to the whole surface of the electrode plate. In the electrochemical process, at the same time there was an electric current at the anode an oxidation reaction would occur against the anion (negative ion), the anode made of aluminum metal would undergo an oxidation reaction to form Al^{3+} ions and would bound ions (OH^-) to form floc $Al(OH)_3$ which could bound Fe_2^+ ions and capture some Fe and Mn metal that was not deposited on the cathode stem. Effect of current and processing time on Fe and Mn content can be seen in Figure 6 and Figure 7.

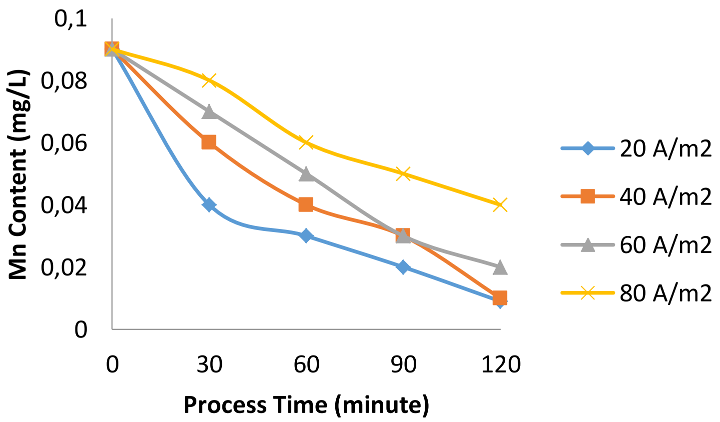


Figure 7. Effect of Current and Processing Time on Mn Content

3.3 Effectiveness of Electrocoagulation Methods in Processing Peat Water

The effectiveness of the electrocoagulation method in processing peat water with parameters of decreasing content of TDS, BOD5, COD, Fe content and Mn content as well as an increased in pH value in this experiment occurred at a current density of 20 A/m^2 with a time of 120 minutes. The smaller the current density, the higher the electrode area so that peat water could be electrocoagulated properly. The processing time also determined the results of peat water process, the longer the processing time, the peat water produced would become more evident. This condition was due to the more prolonged contact with peat water with electrodes. The decreased in the effectiveness of TDS was 42.09%, BOD5 34.36%, and COD 88.89%, while the effectiveness of decreasing Fe metal content and Mn metal content was 55.2% and 90%.

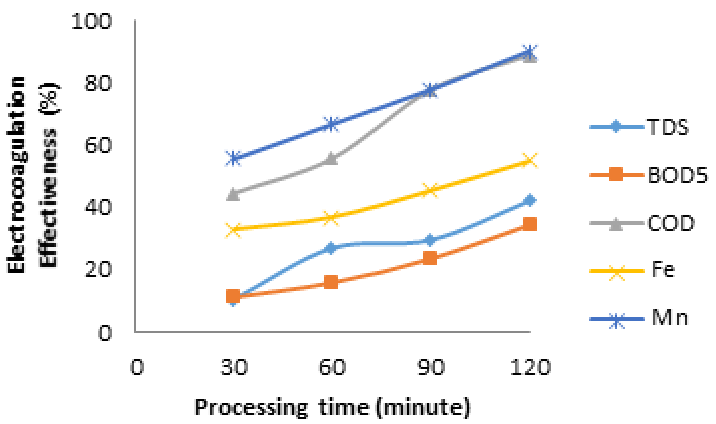


Figure 8. Electrocoagulation Effectiveness on Time at a Current Density of 20 A/m^2

4. Conclusion

Peat water contained in the Integrated Independent City, Ogan Ilir Regency, South Sumatera still requires special processing before being used as a source of water for domestic purposes. Based on the results of the analysis, the pH value and metal content of Fe exceed the environmental quality standards based on the Regulation of the Governor of South Sumatra No. 16 of 2012. The peat water had a slightly acidic pH of 5.59 and a high dissolved Fe metal content of 1.25 mg/L. The TDS value of the peat water was 49.8 mg/L, the BOD5 value was 1.95 mg/L, COD value was 9 mg/L and the Mn content contained was 0.09 mg/L.

One method used to process peat water was by electrocoagulation method. It could be seen, the effectiveness of the reduction of each parameter occurs at a current density of 20 A/m^2 with a processing time of 120 minutes. The decreased in the effectiveness of TDS was 42.09%, BOD5 34.36%, and COD 88.89%, while the effectiveness of decreasing Fe metal content and Mn metal content was 55.2% and 90%.

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